Advanced Data Acquisition System Implementation for the ITER Neutron Diagnostic Use Case using EPICS and FlexRIO Technology on a PXIe Platform

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Extended Abstract– **In the framework of the ITER Control Breakdown Structure (CBS), Plant System Instrumentation & Control (I&C) defines the hardware and software required to control one or more plant systems [1]. For diagnostics, most of the complex Plant System I&C are to be delivered by ITER Domestic Agencies (DAs). As an example for the DAs, ITER Organization (IO) has developed several use cases for diagnostics Plant System I&C that fully comply with guidelines presented in the Plant Control Design Handbook (PCDH) [2]. One such use case is for neutron diagnostics, specifically the Fission Chamber (FC), which is responsible for delivering time-resolved measurements of neutron source strength and fusion power to aid in assessing the functional performance of ITER [3]. ITER will deploy four Fission Chamber units, each consisting of three individual FC detectors. Two of these detectors contain Uranium 235 for Neutron detection, while a third "dummy" detector will provide gamma and noise detection. The neutron flux from each MFC is measured by the three methods:**

- **Counting Mode: measures the number of individual pulses and their location in the record. Pulse parameters (threshold and width) are user configurable.**
- **Campbelling Mode (Mean Square Voltage): measures the RMS deviation in signal amplitude from its average value.**
- **Current Mode: integrates the signal amplitude over the measurement period**

The system requirements specification (SRS) for the neutron diagnostics use case [4] implies the use of technology capable of real-time (RT) digital signal processing (DSP) with the ability to derive timestamps from the ITER IEEE1588 Time Communication Network (TCN). Furthermore, in accordance with ITER specifications for CODAC Core System (CCS) application development, the software responsible for managing the diagnostic system must comply with EPICS Nominal Device Support (NDS). NDS is a software abstraction layer that simplifies the creation of EPICS device drivers, and therefore EPICS Input/Output Controllers (IOCs) for Data Acquisition (DAQ) devices.

To meet the requirements of the SRS, a data acquisition system has been implemented on the PXI Express (PXIe) platform using the following products from the ITER catalog of standard I&C hardware for fast controllers:

- **PICMG 1.3 host computer running CCS software**
- **18-slot PXIe chassis**
- **PXIe module providing PCIe link from chassis to host computer**
- **PXIe timing and synchronization module using IEEE1588 standard**
- **PXIe FlexRIO card with Virtex-5 FPGA (PXIe7966R)**
- **FlexRIO Adapter Module with four 14-bit, 250 MS/s analog inputs (NI5761)**

Data acquisition and preprocessing are performed with FlexRIO technology, which combines high-speed analog-to-digital converters (ADCs) with a user programmable FPGA. Detector signals are acquired simultaneously at 125 MS/s, while filtering, decimation, and the aforementioned neutron counting methods are performed in real-time via the onboard FPGA [5]. At the completion of each 1 ms measurement period, a trigger is sent across the PXIe chassis backplane. Upon receipt of this trigger, the IEEE-1588 module generates a timestamp derived from the TCN.

NDS compliant EPICS device support for generic RIO/FlexRIO devices is provided by ndsRIO. However, to support the specific implementation for the neutron diagnostics use case, ndsRIO has been modified according to documented guidelines [5]. This customized application, ndsRIO-MFC, is responsible for the management, configuration, and monitoring of system devices. Measurements from the FlexRIO module are calibrated on the host side and reported to the Plasma Control System (PCS) every 1 ms via EPICS Channel Access (CA). The last 1000 measurements for any given second are also monitored, and raw signal data is made available for archiving. Figure 1 presents an overview of the primary system components.

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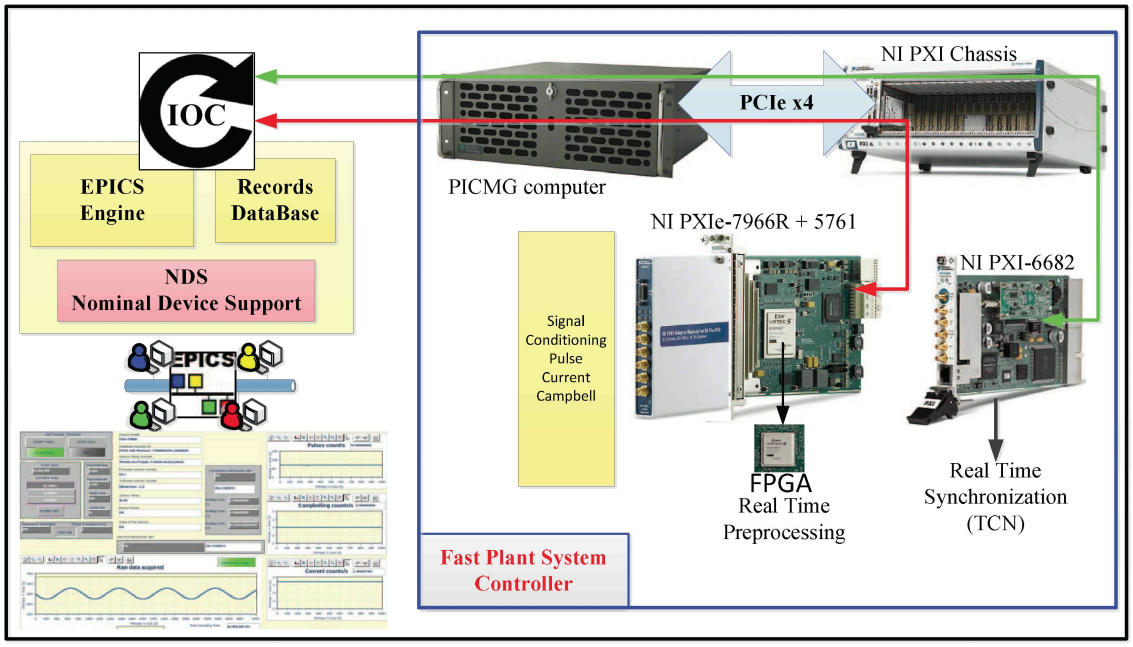

Figure 1. Main elements of the PXIe-based FC Plant System I&C